4.03 OPERATIONS MODELING RESULTS

Operations modeling was carried out for existing conditions, 2030 assuming 1.2 percent annual growth, and 2030 assuming 1.8 percent annual growth. The overall operation of the study corridor was evaluated based on individual intersection operations, queuing, and rural two-lane operations.

A. <u>Measures of Effectiveness</u>

Operations on a street or highway are evaluated using Measures of Effectiveness (MOEs), which determine a Level of Service (LOS). LOS can be between A and F, with A representing near ideal conditions and F indicating very poor conditions (such as gridlock). The operational characteristic that is measured depends on the function of the road at the location in question.

1. Intersection Operations

The operation of a roadway (i.e., congestion levels) is typically described as "Level of Service" (LOS). The LOS rating system describes the traffic flow conditions of a roadway or intersection and ranges from A (free flow conditions) to F (over capacity). In urban areas, intersection operations are the primary evaluation measure for operation levels. Intersection operation is less of a measure of operation in rural areas, but it still provides insight on how difficult entering and crossing the highway is.
For intersections, the LOS is determined by the average delay (in seconds) of all vehicles entering the intersection. The average delay is based on the peak 15-minute period of the peak hour being analyzed. Since this delay is an average value, some vehicles will experience substantially greater delay, and some will experience less delay than the average value. Intersections with short average delays have high LOS; conversely, intersections with long average delays have low LOS. LOS E is considered to be the limit of acceptable delay. An LOS of F for the total intersection is considered to be an indication of the need for improvement. Many communities establish a delay of up to 55 seconds for signalized intersections and 35 seconds for unsignalized intersections, both corresponding to LOS D, as their minimum standard. Therefore, the intersections overall must maintain an LOS D.

LOS characteristics are different for signalized and unsignalized intersections. Drivers anticipate longer delays at signalized intersections that carry large amounts of traffic. However, drivers generally feel unsignalized intersections should have less delay. Additionally, several driver behavior considerations combine to make delays at unsignalized intersections less desirable than at signalized intersections. For example, drivers at signalized intersections are able to relax during the red interval, whereas drivers on the minor approaches to an unsignalized intersection must remain attentive to identify acceptable gaps for entry. Typically, LOS is only calculated for the legs of an unsignalized intersection that have to yield to other movements (stop control or left turns). Figure 4.03-1 describes the Level of Service characteristics for both signalized and unsignalized intersections.

LOS	Signalized Intersections	Unsignalized Intersections
A	Describes intersections with very low levels of delay that average less than 10 seconds per vehicle. This condition occurs with extremely favorable signal progression and most vehicles arrive on the green phase of the signal.	Describes intersections with very low levels of delay that average less than 10 seconds per vehicle.
B	Describes intersections with low levels of delay that are more than 10 seconds yet less than 20 seconds per vehicle. This condition generally occurs with short-cycle lengths and/or good signal progression.	Describes intersections with low levels of delay that are more than 10 seconds yet less than 15 seconds per vehicle.
C	Describes intersections with average delays ranging from 20 to 35 seconds per vehicle. Individual cycle failures (waiting through more than one cycle) may appear at this Level of Service. The number of vehicles stopping is also substantial at this Level of Service.	Describes intersections with average delays ranging from 15 to 25 seconds per vehicle.
D	Describes intersections with average delays ranging from 35 to 55 seconds per vehicle. The influence of congestion becomes more noticeable. This Level of Service may result from long-cycle lengths, unfavorable progression and/or high vehicle-to-capacity ratios. Many vehicles stop and the proportion of nonstopping vehicles declines. Individual cycle failures are noticeable.	Describes intersections with average delays ranging from 25 to 35 seconds per vehicle. The influence of congestion becomes more noticeable.
E	Describes intersections with average delays ranging from 55 to 80 seconds per vehicle. Individual cycle failures are frequent occurrences. This Level of Service is considered by most agencies to be the limit of acceptable delay.	Describes intersections with average delays ranging from 35 to 50 seconds per vehicle.
F	Describes intersections with average delays that are more than 80 seconds per vehicle. This Level of Service, considered to be unacceptable by most drivers, often occurs with oversaturation. The number of vehicles entering the intersection exceeds the intersection's capacity.	Describes intersections with average delays that are more than 50 seconds per vehicle. LOS F exists where there are insufficient gaps of suitable size to allow side-street traffic to cross safely through a major street traffic stream. This LOS is usually evident from extremely long total delays experienced by side-street traffic and queuing on the minor approaches.

Source: 1997 Highway Capacity Manual

Figure 4.03-1 Level of Services Characteristics from 1997 HCM

2. Queuing

Queuing at intersections becomes a concern as traffic volumes increase and LOS decreases. When queues begin to block adjacent intersections, traffic operations will rapidly deteriorate and safety concerns rise. Long queues decrease vehicle fuel efficiency and increase air pollution.

3. Two-lane Operations

In rural areas, the operation of a roadway is primarily characterized by a two-lane operations analysis. With this analysis, the level of service is largely determined by the ability of drivers to travel at their desired speed and the ability to pass slow-moving vehicles when necessary. Platooning occurs when travelers are not able to travel at their desired traveling speed because of a slow-moving vehicle in front of them. The amount of platooning that occurs on a highway is a function of the volume of vehicles on the highway, the makeup of those vehicles, the number of passing opportunities available, and the amount of opposing traffic. Platooning is relieved when vehicles are able to pass the slow-moving vehicle. Passing demand increases as the traffic volumes increase. Yet the ability to pass in the opposing lane declines as traffic volumes increase. A two-lane highway's passing capacity is highly dependent on the opposing traffic stream. Motorists are forced to change their individual travel speed as volumes increase and the ability to pass declines.

Two operational measures, average speed and percentage delay time, are used to describe the quality of service provided to motorists on a two-lane highway. Figure 4.03-2 describes the range of LOS that can be attained on two-lane highways. LOS A is the highest quality of traffic service, and LOS F is the lowest quality of service.

B. Existing Operations

Operations modeling of the existing conditions indicated that the study corridor is operating within

LOS	Two-Lane Highway
A	Highest quality of traffic service, where motorists are able to drive at their desired speed. Average speeds of 60 mph. Drivers would be delayed no more than 30% of the time by slow-moving vehicles.
B	On average, drivers are delayed up to 45% of the time. Service flow rates of 750 pcph, total in both directions, can be achieved under ideal conditions. Speeds of 55 mph or slightly higher are expected on level terrain.
C	Noticeable increases in platoon formation, platoon size, and frequency of passing impediment. Percent delays are up to 60%. Average speed still exceeds 52 mph on level terrain, even though unrestricted passing demand exceeds passing capacity.
D	Passing demand is very high, while passing capacity approaches zero. Mean platoon sizes of 5 to 10 vehicles are common, although speeds of 50 mph can still be maintained under ideal conditions. The fraction of no passing zones along the roadway section usually has little influence on passing. The percentage of time motorists are delayed approaches 75%.
E	Defined as traffic flow conditions on two-lane highways having a percent time delay of greater than 75%. Maximum flow rates of 1,800 pcph, total in both directions, can be maintained under ideal conditions. This is the highest flow rate that can be maintained for any length of time over an extended section of level terrain without a high probability of breakdown.
F	As with other highway types, LOS F represents heavily congested flow with traffic demand exceeding capacity. Volumes are lower than capacity, and speeds are below capacity speed. LOS E is seldom attained over extended sections on level terrain as more than a transient condition; most often, perturbations in traffic flow as level E is approached cause a rapid transition to level-of-service F.

Source: 1997 Highway Capacity Manual

Figure 4.03-2 Two-Lane Highway Operational Characteristics

acceptable limits at most locations. Figures 4.03-3 and 4.03-4 in show the existing corridor operations schematically.

Intersection operations throughout the corridor were generally at an acceptable LOS C or higher during both the AM and PM peak hours. Full intersection analysis was completed for the following intersections:

- Signalized: CTH MN
  STH 138 South/Van Buren Street
  Page Street
  Division Street
  Fourth Street
  CTH N

- Unsignalized: Exchange Street
  Mahoney Drive
  Dyreson Road
  CTH B West/CTH AB
  Schneider Drive
  Lake Kegonsa Road
  CTH B East
  Rutland-Dunn Townline Road
  Roby Road
  STH 138 West
  Hoel Avenue

The poorest operations were observed on CTH B East during the AM peak hour, which operated at LOS E. Traffic on CTH B East wishing to enter USH 51 experienced average delays of approximately 36 seconds during this period. The STH 138 West and Hoel Avenue intersections both operated at LOS D during the PM peak hour with average delays of approximately 30 seconds each.

Modeling did not indicate queuing concerns during either peak hour in 2003.

Figure 4.03-3 – Operations Modeling Results – AM Peak Hour Existing Conditions

Figure 4.03-4 – Operations Modeling Results – PM Peak Hour Existing Conditions

Analysis of the rural two-lane sections of USH 51 indicated that the highway operates in the LOS D range between McFarland and Stoughton during both the AM and PM peak hours. Average travel speeds dropped to as low as 45 mph in the 2003 modeling. Two-lane operations east of Stoughton were better than LOS C.

C. 2030 Assuming 1.2 Percent Annual Growth

Upon completion of the existing conditions modeling, the study team loaded the 2030 traffic volumes that were projected assuming 1.2 percent annual growth (see sections 3.04 and 3.05) from the demand model into the existing corridor operations model. Minor changes to signal timings were made, and signals were added to the Roby Road intersection. No geometric changes were made to USH 51 in the model. The 2030 modeling assuming 1.2 percent annual growth showed significant increases in congestion and queuing and decreases in LOS and operational efficiencies. Figures 4.03-5 and 4.03-6 in show the corridor operations schematically.

Six of the unsignalized intersections analyzed had minor street approaches that operated at LOS F during the AM and PM peak hours:

- Exchange Street – average delays on side streets: 120 to 180 seconds.
- CTH B West/CTH AB – delays: 80 seconds to over 180 seconds.
- CTH B East – delays: 80 seconds to over 180 seconds.
- Rutland-Dunn Townline Road – delays: over 180 seconds.
- STH 138 West – delays: 60 seconds to 100 seconds.
- Hoel Avenue – delays: 90 seconds to over 180 seconds.

In addition to the intersections above with minor street approaches that operated at LOS F during both peak hours, other intersections had minor approaches that failed in only one of the peak hours. Schneider Drive's minor approaches operate between LOS E and LOS F during the AM and PM peak hours, respectively. The Dyreson Road and Lake Kegonsa Road intersections operated at LOS F during the PM peak hour.

Operations at the signalized intersections analyzed were LOS C or better overall during both time periods. However, some of the individual approaches at various intersections operated below LOS C, as shown in Table 4.03-1.

Peak Hour	Intersection	Approach	LOS
AM	Division Street	South	D
		East	D
	Fourth Street	South	D
	CTH N	South	F
PM	STH 138 South	East	D
	Division Street	South	D
		East	D
	Fourth Street	East	D
	CTH N	West	F

Table 4.03-1 Operations of note on Specific Signalized Intersection Approaches – 2030 Assuming 1.2 Percent Growth

Figure 4.03-5 – Operations Modeling Results – 2030 AM Peak Hour Assuming 1.2% Growth

Figure 4.03-6 – Operations Modeling Results – 2030 PM Peak Hour Assuming 1.2% Growth

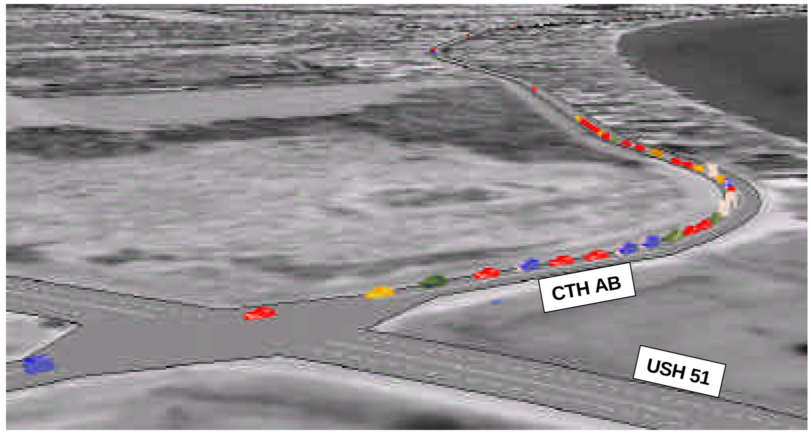

Figure 4.03-7 Queuing on CTH AB During the AM Peak Hour - 2030 Assuming 1.2 Percent Annual Growth

The 2030 modeling indicated that queuing at intersections throughout the corridor would become a problem when the study corridor experiences the traffic volumes projected assuming 1.2 percent annual growth. Queues on at least one of the minor street approaches at the CTH B West/CTH AB, CTH B East, and Rutland-Dunn Townline Road intersections reached more than 1,000 feet in length during the AM peak hour (see Figure 4.03-7). During the PM peak hour, southbound left-turning vehicle queues at CTH MN in McFarland spilled out of the dedicated left turn bay's storage area. As a result, vehicles blocked USH 51's southbound through lanes, decreasing capacity.

PM peak hour queuing within Stoughton sometimes blocked adjacent side streets, as shown in Figure 4.03-8. The grid street network in downtown Stoughton was at risk for gridlock due to the heavy volumes and large amounts of turning traffic. Local side streets within Stoughton experienced substantial traffic increases from 2003 to 2030 because drivers were seeking alternate routes to and from USH 51. The additional vehicles on Stoughton side streets represent people that elect to continue using USH 51 as their primary route choice. TRANPLAN modeling accounted for those drivers that choose to use alternate highways such as STH 138 or CTH N in

Figure 4.03-8 Queuing on USH 51 in Downtown Stoughton During the PM Peak Hour - 2030 Assuming 1.2 Percent Annual Growth

the step prior to operations modeling.

One statistic that is used to evaluate two-lane operations is the Volume to Capacity ratio (v/c). This is the ratio of the traffic volume on the roadway (v) to the total capacity of the roadway (c) at a given location. When this ratio is greater than 1.0, it indicates that a roadway is operating above its intended capacity. The v/c ratios between Stoughton and McFarland were between 0.72 to 0.83 when experiencing 2030 volumes assuming 1.2 percent growth, corresponding to LOS E during both peak hours. Large volumes of traffic in both directions during the AM and PM peak hours made passing on this rural stretch of USH 51 very difficult. Average travel speeds decreased to approximately 40 mph at times. East of Stoughton, modeling indicated that two-lane operations would remain at acceptable levels.

D. <u>2030 Assuming 1.8 Percent Annual Growth</u>

Upon completion of the 2030 operations modeling using 1.2 percent annual growth, the study team loaded the traffic volumes based on 1.8 percent growth (see sections 3.04 and 3.05) from the demand modeling into the operations model. Again, minor changes to signal timings were made to reflect the types of capacity improvements that might be made in lieu of roadway expansion. No geometric changes were made to USH 51 in the model. The 2030 modeling assuming 1.8 percent annual growth showed additional increases in congestion and queuing and decreases in LOS and operational efficiencies when compared with the 2030 modeling assuming 1.2 percent growth. Figures 4.03-9 and 4.03-10 show the corridor operations schematically.

Nine of the unsignalized intersections analyzed had minor street approaches that operated at LOS F during both the AM and PM peak hours:

- Exchange Street – average delays on side street: Over 180 seconds.
- Dyreson Road – delays: Over 180 seconds.
- CTH B West/CTH AB – delays: 160 seconds to over 180 seconds.
- Schneider – delays: 90 seconds to over 180 seconds.
- Lake Kegonsa Road – delays: 70 to 100 seconds.
- CTH B East – delays: Over 180 seconds.
- Rutland-Dunn Townline Road – delays: Over 180 seconds.
- STH 138 West – delays: Over 180 seconds.
- Hoel Avenue – delays: 120 to over 180 seconds.

Overall operations at the signalized intersections varied throughout the corridor and from the AM to the PM peak hours. During the AM peak hour, the STH 138 South and the CTH N intersections operate at LOS F overall. During the PM peak hour, the STH 138 South and the Division Street intersections operate at LOS D overall, while the CTH MN intersection in McFarland operated at LOS F. Table 4.03-2 shows individual approach operations at various intersections.

Figure 4.03-9 – Operations Modeling Results – 2030 AM Peak Hour Assuming 1.8% Growth
Figure 4.03-10 – Operations Modeling Results – 2030 PM Peak Hour Assuming 1.8% Growth

Concerns with queuing continued to worsen throughout the study corridor using the 2030 traffic assuming 1.8 percent annual growth. Queues greater than 1000 feet in length became common on the side streets at unsignalized intersections during both the AM and PM peak hours. During the AM peak hour, queues on northbound STH 138 at USH 51 became long enough to block adjacent intersections with STH 138, causing further undue delay on the adjacent local street system. Queuing on eastbound USH 51 at CTH N, as shown in Figure 4.03-11, reached more than 1000 feet in length.

Peak Hour	Intersection	Approach	LOS
AM	Division Street	East	D
	Fourth Street	South	D
PM	Roby Road	East	D
	Page Street	South	D
	Divison Street	West	D
		South	E
		East	E
	Fourth Street	South	D
		North	D
		East	D

Table 4.03-2 Operations of note on Specific Signalized Intersection Approaches – 2030 Assuming 1.8 Percent Annual Growth

During the PM peak hour, queue lengths at CTH MN continued to increase and became a safety concern for southbound USH 51 traffic entering McFarland. This traffic travels on a freeway that transitions to an urban roadway south of the Siggelkow Road interchange. Queuing at CTH MN shortens this transition distance (see Figure 4.03-12). Queuing within Stoughton continued to worsen and gridlock became commonplace during the second half of the PM peak hour simulations.

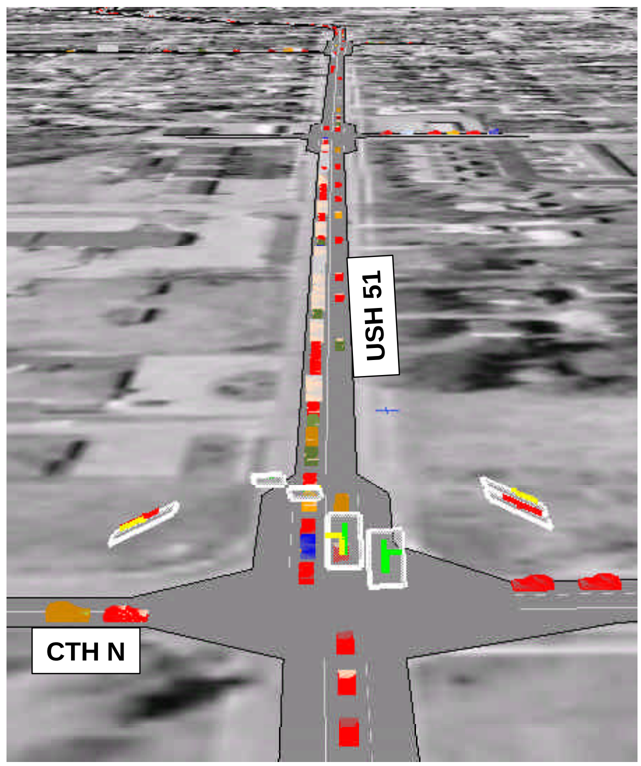

Figure 4.03-11 Queuing on Eastbound USH 51 at CTH N During the AM Peak Hour – 2030 Assuming 1.8 Percent Annual Growth

Two-lane operations between Stoughton and McFarland remained at LOS E during both peak hours but, in some instances, were very near the LOS F threshold. For a two-lane roadway, LOS F occurs when volume is greater than capacity (v/c > 1.0). During the PM peak hour between the CTH B East and CTH B West/CTH AB intersections, the v/c ratio was 0.92, indicating that the highway was very near LOS F operations. Large volumes of traffic in both directions during the AM and PM peak hours made passing on rural USH 51 very difficult. Average travel speeds decreased to approximately 35 mph at times. East of Stoughton, modeling indicated that two-lane operations remained at acceptable levels.